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CEREAL RUST NURSERIES IN THE CARIBBEAN AREA, 1950-72

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Many people have been involved in the program since 1950. H. A. Rodenhiser made the initial contacts and Federal interagency cooperative agreements. He also coordinated the program up to 1966. Since 1957, the overall program has been under the leadership of L. P. Reitz. Persons located in Puerto Rico who helped in managing and carrying out this program are T. Theis, D. V. McVey, J. D. Miller, and F. A. Jimenez. Others who assisted in note taking, preparation of seed or distribution of reports are: B. B. Bayles, C. V. Lowther, C. E. Minarik, J. C. Craddock, W. Q. Loegering, C. E. Peet, B. J. Roberts, G. J. Greene, C. H. Kingsolver, W. F. Kernkamp, G. Fleischmann, J. F. Schafer, I. M. Atkins, A. G. Norman, D. R. Johnston, E. L. Kendrick, E. Stone, M. E. McDaniel, L. W. Briggle, H. L. Shands, R. T. Smith, V. Goodfellow, L. Calpouzas, D. E. Western, D. G. Fletcher, W. Gaud, and R. A. Kilpatrick. Appreciation is expressed to all for their contribution.

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ABSTRACT

Wheat has been grown experimentally since 1950, oats since 1954, and barley one year in the Caribbean area to determine their reaction to cereal rust fungi. The reaction with 13 races and four biotypes of stem rust affecting wheat, 11 races and two biotypes of crown rust and two races and two biotypes of stem rust affecting oats has been determined at the rate of two to five cultures per year on a total of 56,857 wheats and 67,543 oats. Barley received only slight attention because plants and rust developed poorly. Supplemental light and vernalization enhanced the opportunity to obtain the adult reaction. Resistance to the virulent cultures of rust was identified, and some resistance was incorporated into desirable agronomic selections of wheat and otas. Problems related to testing wheat, oats, and barley in the Caribbean area are discussed.

CEREAL RUST NURSERIES IN THE CARIBBEAN AREA, 1950-72

By R. A. Kilpatrick, L. P. Reitz, and F. A. Jimenez[1/]

Commercial wheat (Triticum aestivum L.), oats (Avena sativa L.), and barley (Hordeum vulgare L.) are plagued by leaf and stem rust almost everywhere the crops are grown. Many pathogenic cultures or biotypes of each rust organism occur and new ones frequently develop. Varietal resistance within each species is known to many but not all biotypes. Genes that control seedling and adult resistance are sometimes different. Seedling resistance can be determined easily in the greenhouse or growth chamber but adult plant reaction (plants in the heading or later stages of development at the time of making readings) to specific biotypes is more of a problem because of space required and difficulties in management of the plants.

Field evaluation of wheat and oats provide the most accurate method for determining adult reaction to the rusts. Field studies with virulent biotypes of rusts are hazardous when done in the commercial crop area. Hence, a lag frequently occurs in testing for resistance to new cultures. The everpresent rusts prevent pure culture determination out-of-doors in most areas of the world. The severe epidemic of wheat stem rust (Puccinia graminis Pers. f. sp. tritici Eriks. & E. Henn.) race 15B, which occurred in the United States in 1950, focused attention on the need for field testing of wheats to determine varietal reaction to virulent biotypes of P. graminis tritici. A suitable location was found in the Caribbean area. The objective of this publication is to summarize work for the period 1950 to 1971 and to show the location of plantings, number of entries, plots, sources of seed, pedigree of resistant entries, and how problems relating to testing in Puerto Rico were overcome. This report should be of value to research workers on other disease problems where outdoor testing is desired under conditions that do not endanger commercial crops in the locality.

MATERIALS AND METHODS

The initial planting site was selected at the Christiansted Experiment Station, St. Croix, V. I. (fig. 1). This location provided the ideal climate with the temperature ranging from 65° to 85° F. and the relative humidity

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1/ Research plant pathologist, Germplasm Resources Laboratory, Northeastern Region, and staff specialist, National Program Staff, Agricultural Research Service, Beltsville, Md.; and research technician, Southern Region, Agricultural Research Service, Mayaguez, P.R., respectively.

up to 100 percent nearly every night during the growing season. Similar excellent test sites were located in Puerto Rico. Such conditions of temperatures and dew deposits of 8 hours or more per night during February through March were ideal for development of stem and leaf rust.[2/] In addition, small grains and grass hosts of the rusts were not grown on this or surrounding islands; therefore, the chances of wind-blown contamination were minimimized. Negotiations between the U.S. Departments of Agriculture and Interior in the summer of 1950 were successful and the first nursery was planted that fall.

The initial material was planted at St. Croix and consisted of the Uniform Rust Nurseries. Material for later years was obtained from the World Collection of Small Grains, 75 countries supplying material for the International Rust Nurseries, and from plant breeders and pathologists within the United States, Canada, and Mexico. The first nursery was made up of 121 wheats, 32 oats, and 43 barleys. Seeds were planted on three dates--November 11 and December 2 and 20. All plots were seeded in 5-foot rows. Recently, because of labor shortages, plots have been hill plantings. Supplemental fertilization was omitted the first year, but used in later years (10-10-10 at the rate of 500 lb./acre). To hasten plant growth and fungus development, plots were irrigated when conditions warranted.

Cultures used for the different locations were selected upon the recommendations of personnel of the Cereal Rust Laboratory, St. Paul, Minn. (E. C. Stakman, D. M. Stewart, R. W. Romig, A. P. Roelfs, P. Rothman, and J. B. Rowell) and oat investigators at Ames, Iowa (H. C. Murphy and M. D. Simons). From among the most virulent biotypes, based on annual U.S. rust surveys, two to five cultures were selected each year for use in these nurseries.

The method of inoculation was standardized. Border rows of a known susceptible wheat cultivar, generally Baart, Mentana, or Lemhi, and Markton oats, were planted around the nursery and as spreader rows within the test area. Approximately 6 weeks after seeding, plants in the borders were inoculated by hypodermic injection of a uredospore suspension. To avoid possible interaction of biotypes, all cultures were inoculated separately when two or more were used in the same test nursery. Once plants were inoculated, sanitary conditions were practiced to prevent human cross contamination of nurseries from spores that might be carried on clothing or tools.

The optimum date for recording notes was approximately 6 weeks after inoculation. Plants of each entry were evaluated on the basis of percentage severity and host response. Arbitrary values were assigned for the different responses. By multiplying the percentage severity and response, an average disease coefficient varying from zero (no infection) to 99 (highly susceptible) was obtained. For this report, all entries, or selections, having an average disease coefficient of 2 or less are included in table 1 and 2.

2/ Calpouzos, L., Theis, T., Colberg, C., Rivera, C. M., and Santiago, A. Relationship Between Climatic Factors and Incidence of the Sigatoka Leaf-Spot Disease of Bananas. U.S. Plant Dis. Rptr. 46: 758-761. 1962.

EXPERIMENTAL RESULTS

Wheats

The results obtained from the 1950 tests were most encouraging and laid the foundation for justifying the continuation of the Rust Nursery Program in the Carribean area. Growth of spring and durum wheats was considered good, but winter wheats remained in the rosette stage. The November planting date was considered best of the three dates of planting. Later planting dates varied from November 15 to December 20, depending on weather conditions. Severe infection developed on susceptible wheats. In addition, leaf infection was more severe than that normally observed under field conditions. Rust samples revealed no contamination of biotypes; only races 17 and 56 were introduced and only these were recovered. Of the 121 wheats tested, 18 percent had an average disease coefficient of 2.0 or less. Examination of the varieties and crosses revealed that stem rust resistance was highest in entries involving Frontana, T. timopheevii (Zhuk.) Zhuk., Vernum, Rio Negro, Fronteira, Red Egyptian, Lee, Atlas 66, Wis. 245, Tim. X Newthatch, Egypt NA 101, Spelmar, Beladi 116, and Kenya selections. These sources later formed the basis of many breeding programs around the world.

Information pertaining to nurseries planted in the Virgin Islands and Puerto Rico since 1950 are given in table 1. This information will be discussed in the following topics:

Location.--The St. Croix nurseries of 1950 to 1954 yielded much new information on varietal reaction to the different biotypes. Planting at this location also resulted in problems relating to moving equipment back and forth from Mayaguez. Because of the inefficiency of management and a reduced budget, the St. Croix location was eliminated and locations within the island of Puerto Rico expanded in 1956.

Five suitable, yet isolated, locations were utilized in Puerto Rico (fig. 1). Even though some locations were separated by as little as 15 miles, no cross contamination of any consequence occurred.

Number of plots, entries, and sources of seed.--Since 1950, the program has required 120,879 plots or rows representing 56,857 entries. These entries included named cultivars, Plant Introduction accessions, and genetic materials from 75 countries and 40 States. The large nurseries of 1952-53 included all wheats in the World Collection of Small Grains at that time. Since then, many Plant Introductions have been included in this program. Nurseries in individual years also included as many as 250 to 1,000 entries from individual breeders or States. The number submitted by an individual or State affects the percentage of entries with an average disease coefficient of 2 or less.

Races used.--The races of wheat stem rust used in this program were among the most virulent races that have occurred within the United States since 1950. Changes in virulence have occurred between and within races. Virulence within races 11, 17, 38, 48, 49, 56, and 139 is common although the most virulent biotypes have been identified in races 15B, 32, and 151. The increased number

Table 1.--General information on wheat rust nurseries planted in the Virgin Islands and Puerto Rico, 1950-72

Year and location	Number of rows per location	Total number of different entries	Race used	Percent resistant	Sources of seed	
					Countries	States
					Number	Number
1950-51, St. Croix, V.I.	121	121	56+17	18	---	---
1951-52, St. Croix, V.I.	4,876	4,876	15B	4	57	26
1952-53:						
St. Croix, V.I.	10,131	10,131	11+49	5	63	37
Mayaguez, P.R.	10,131		15B+17+32 +38+56+139	3	---	---
1953-54:						
St. Croix, V.I.	749	2,996	49	13	30	9
Mayaguez, P.R.	749		11	36	---	---
Roosevelt Rd.	749		15B	39	---	---
Isabela	749		139	22	---	---
1954-55:						
St. Croix, V.I.	532	2,660	11+15B+49+56	16	31	7
Mayaguez, P.R.	532		29	35	---	---
Isabela	532		11	43	---	---
Rio Piedras	532		56	27	---	---
Lajas	532		48	25	---	---
1955-56, no data	---	---	---	---	---	---
1956-57:						
Isabela	220	220	15B	71	1	2
Lajas	220		29	62	---	---
1957-58:						
Isabela	1,115	1,115	15B	52	20	4
Aguirre	479		11	54	---	---
Lajas	1,115		29	46	---	---
1958-59:						
Mayaguez	2,075	2,075	Composite of races	---	21	16
Isabela	2,075		15B	42	---	---
Lajas	2,075		11	72	---	---
Ponce	2,075		15B	---	---	---

Table 1.-- Continued

Year and location	Number of rows per location	Total number of different entries	Race used	Percent resistant	Sources of seed: Countries	Sources of seed: States
					Number	Number
1959-60:						
Mayaguez	2,982	4,375	29	77	38	12
Isabela	4,375		15B	50		
Ponce	2,651		15B	46		
Lajas	2,548		11	54		
1960-61:						
Isabela	1,600	1,600	15B	53	38	12
Ponce	1,560		15B	54		
Lajas	1,560		11	45		
1961-62:						
Mayaguez	1,331	1,331	11	42	16	10
Isabela	1,331		15B	45		
Ponce	1,331		15B	57		
1962-63:						
Mayaguez	2,796	3,312	56	46	21	10
Isabela	2,131		15B	45		
Ponce	1,649		15B	28		
1963-64:						
Mayaguez	2,209	2,330	32B	36	19	4
Ponce	1,730		15+17A+29 +32A+38+87	44		
Isabela	2,329		15B	36		
Lajas	1,610		15	65		
1964-65:						
Mayaguez	1,375	5,440	11+32 (10 cultures)	25	22	7
Ponce	1,375		87	26		
Isabela	1,375		15B	53		
Lajas	1,375		32	25		
1965-66:						
Mayaguez	1,700	2,060	32B	35	27	8
Ponce	2,060		151	36		
Isabela	2,060		15B-4	12		
Lajas	2,060		Composite (8 cultures)			

Table 1.-- Continued

Year and location	Number of rows per location	Total number of different entries	Race used	Percent resistant	Sources of seed: Countries	Sources of seed: States
					Number	Number
1966-67:						
Mayaguez 1/	1,479	1,479	32B	43	28	9
Ponce	1,479		151	24		
Isabela	1,479		15B-4	35		
Lajas	1,479		Composite	41		
1967-68:						
Mayaguez 2/	1,610	1,610	32B	57	26	9
do 1/	174		32B			
Isabela	1,610		151	43		
Lajas	1,610		Composite (6 cultures)	49		
1968-69:						
Mayaguez 1/	400	1,860	32	27	31	18
do 2/	1,170		32			
do 3/	290		32			
do 4/	290		32			
Lajas	1,860		151	31		
1969-70:						
Mayaguez 1/	270	1,820	15B-6	41	23	8
do 1,3/	320		15B-6			
Isabela	1,210		15B-6	35		
Lajas 5/	310		32+151	43		
do	1,480		32+151			
1970-71:						
Mayaguez 1,3/	1,035	2,834	15B-6	42	35	19
Isabela	1,799		15B-6	-		
Lajas 5/	2,834		32	65		
1971-72:						
Mayaguez 1,3/	724	2,612	151	22	42	21
Isabela	1,888		151	55		
Lajas	2,612		32	43		
Total	120,879	56,857	---	---	75	40

1/ Supplemental light.
2/ No supplemental light.
3/ Supplemental light + seed vernalized.
4/ Supplemental light, seed not vernalized.
5/ No supplemental light, but seed vernalized.

Table 2.--General information on oat rust nurseries planted in Puerto Rico, 1957-72

U.S. DEPT. OF AGRICULTURE

Year and location	Number of rows per location	Total number of different entries	Race used	Percent resistant	Sources of seed: Countries	Sources of seed: States
					Number	Number
1957-58, Isabela	4,804	4,804	264	2	61	44
1958-59:						
Isabela	4,700	6,594	264	4	13	14
Mayaguez	536		264			
Lajas	1,209		290	16		
Ponce	594		216	8		
1959-60:						
Isabela	5,695	6,906	264	12	12	21
Mayaguez	4,986		290	6		
Ponce 2/	1,488		13A (R93)	1		
do 3/	433		13A			
1960-61:						
Isabela	5,001	6,675	264	5	2	14
Ponce	4,900		294	27		
Lajas	472		13A	4		
1961-62:						
Isabela	4,784	6,650	264	18	2	16
Mayaguez	2,237		6A (R87)	4		
Ponce	1,966		321	23		
1962-63:						
Isabela	3,270	4,543	264	13	2	13
Mayaguez	1,398		6A+13A	26		
Ponce	3,553		290	25		
Lajas	411		6A	23		
1963-64:						
Isabela	4,830	7,940	264	12	11	21
Lajas	2,640		6AF (R31)	2		
Ponce	3,025		6A+13A	1		
1964-65:						
Isabela	1,513	2,810	6AF	13	10	16
Mayaguez	2,155		264	12		
Lajas	1,562		6AFH (R94)	9		

PROCUREMENT SECTION
CURRENT SERIAL RECORDS

Table 2.-- Continued

Year and location	Number of rows per location	Total number of different entries	Race used	Percent resistant	Sources of seed: Countries	Sources of seed: States
					Number	Number
1965-66:						
Isabela	2,100	4,040	6AF	7	12	19
Mayaguez	3,680		264	13		
Lajas	2,060		6AFH	17		
1966-67:						
Mayaguez 4/	1,226	2,215	6AFH	0.2	11	15
do 5/	1,484		264	6		
Lajas	1,121		Composite	19		
1967-68:						
Mayaguez 4/	1,960	1,960	6AFH	1	9	14
do 5/	2,250		296+324 +392	6		
1968-69:						
Mayaguez 4/	1,451	1,451	264	8	9	11
Lajas	1,451		203+264B +326+332	6		
1969-70:					7	16
Mayaguez 4/	1,560	3,110	264	6		
Isabela	1,560		264			
Lajas	3,110		264B	11		
1970-71:					7	17
Mayaguez 4/	1,470	5,610	6AFH	30		
Isabela	2,340		6AFH			
Lajas	4,590		264B-Asc.	18		
1971-72:						
Mayaguez 4/	990	2,235	305+326	12	6	13
Isabela	1,121		305+326	30		
Lajas	1,948		264B	26		
Total	105,634	67,543	---	---	---	---

1/ Races 6 and 13 (plus letters A, and so forth) are stem rust; all others are crown rust.
2/ Adult reaction.
3/ Seedling reaction.
4/ Supplemental light.
5/ No supplemental light.

of biotypes within 15B, 32, and 151 may be due to better differential cultivars for greater separation of cultures or to natural increase of virulent biotypes in nature. Employees in the Cereal Rust Laboratory at St. Paul maintain a constant vigilance for virulent cultures of stem rust. Their importance to the Rust Nursery Program in Puerto Rico and to the wheat and oat farmers in the United States cannot be overemphasized.

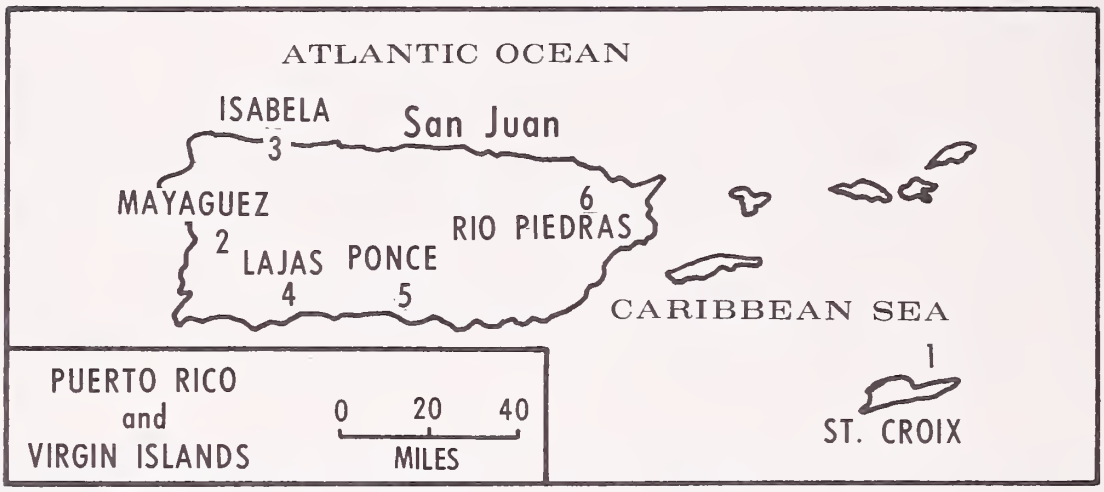
Resistance.--The early tests of 1950 to 1954 showed that many selections possessed the desired genes for resistance to virulent biotypes of P. graminis tritici. Later studies in the greenhouse and in Puerto Rico have confirmed these results. Breeders in the United States and in foreign countries have utilized many of these cultivars in their programs. Selections from Minnesota, North Dakota, Nebraska, Colorado, Canada, Mexico, Kenya, and other areas of the world where these resistant sources were used, continue to be outstanding in their reaction to the different United States biotypes of stem rust. However, the ever changing picture of the rust population emphasizes the need for continual field and greenhouse testing of wheats to the more virulent biotypes of stem rust as they appear.

Problems related to testing wheats in Puerto Rico--Growth types.--The selections of wheat tested in Puerto Rico are diverse in types of growth, day-length requirements, and many other characteristics. The day-length in Puerto Rico varies from 11 to 13 hours and temperatures at planting sites fail to drop below 57° F. This means that wheats must be treated differently to obtain the adult reaction on all plants at the same time. The 1950 tests and later years showed that winter wheats failed to develop beyond the rosette stage of growth. The 1968-69 tests included winter wheats that had been vernalized (a separate report is being prepared by the author on this subject). Material was placed in an incubator for 7 weeks (45° F.), shipped to Puerto Rico, and transplanted to peat pots in the greenhouse. Two weeks later the plants were transplanted to the field. Of the winter selections, 74 percent headed when grown without supplemental light. Plants grown at Mayaguez received supplemental light beginning in 1966. This supplemental lighting consisted of four mercury vapor lamps operating from 10 p.m. until 3 a.m. each night, beginning at the time of inoculation or approximately 6 weeks after seeding. The intensity was 3 ft.-c. at 1-ft. height. The additional light induced heading in a larger percentage of winter and spring types over those grown without supplemental light. When supplemental light was used, 96 percent of the vernalized winter wheats headed. The results on vernalization and supplemental light have justified continuing vernalizing winter wheats. A separate manuscript on use of supplemental light for growing wheats in Puerto Rico is being prepared.

Mexican wheats are day-length insensitive and heading occurs before that of other types. Often, these plants are mature by the time other plants are rated for rusts. To counteract this, Mexican common and durum wheats are planted approximately 2 weeks after the regular seeding. Although the plants do not become large, readings on the adult reaction normally are possible.

Hill vs. row planting.--Advantages and disadvantages to both types of planting were found. The limiting factors are space and labor. Row planting requires more space and labor during the growing season; yet, seed mixtures

CEREAL RUST NURSERIES IN THE CARIBBEAN AREA, 1950-72



KEY

VIRGIN ISLANDS
1 - ST. CROIX

PUERTO RICO
2 - MAYAGUEZ
3 - ISABELA
4 - LAJAS
5 - FORTUNA (PONCE) (AGUIRRE)
6 - RIO PIEDRAS

ROOSEVELT ROAD IS AT THE EASTERN TIP OF PUERTO RICO

Figure 1.--Test locations.

and segregation are more easily observed. Row planting also provides higher humidity due to less air movement and a better environment for rusts to develop. However, under Puerto Rican conditions of long dew deposits and frequent showers during February and March, this is not a critical factor. The primary advantages of hill planting are the reduced space requirement and labor for maintenance of the nurseries, and the ease of handling vernalized seedlings. These have been the decisive factors for use of hill planting since 1970.

Weed control.--Labor for weeding plots accounted for a large part of the cereal crops budget in Puerto Rico before 1969. Preliminary tests were made on different herbicides but Diuron was the only one that appeared promising. Broad leaf weeds and grasses were controlled successfully when Diuron was used as a preemergence treatment at the rate of 1 pound per acre.

Contamination of plots.--Sanitary conditions are essential in managing these nurseries. The critical period is after rust develops. Workers going from one location to another must be instructed in the ways contamination may occur and how to take necessary precautions. Throughout the 20 years that these tests were conducted, very little contamination occurred although one whole test was abandoned on this account. Some difficulty resulted because the cultures were unpure before shipment to Puerto Rico. Cultures foreign to the United States were never detected in samples sent for identification and, generally, only races known to be in the inoculum used were recovered at the end of the season.

Leaf rust.--Leaf rust on wheat, P. recondita Rob. ex Desm. f. sp. tritici, was observed in 5 of 20 years' testing. The origin is unknown. According to Roure, no alternate hosts of P. recondita are known to occur in Puerto Rico.3/ Identification of collections in one year turned out to be UN2, a race common in the United States. It is possible that Stem rust cultures may have been contaminated before being sent to Puerto Rico.

Helminthosporium leaf spot.--A leaf spot, typical of Helminthosporium, appeared on wheat planted in Puerto Rico. On some plants, a small rust pustule occurred in the center of the necrotic lesions. On others, which were known to be susceptible, only leaf and stem spotting occurred. Such plants were rated as escapes. In 1972, leaf and stem spotting was severe on some entries. A dark black discoloration on one side of the stems indicated a heavy inoculum potential. The fungus was identified as H. sorokinianum Sacc. in Sorok.4/ Stewart and Hill5/ showed that H. sorokinianum produces a toxin that inhibits germination of P. graminis tritici uredospores, a disease apparently important in Puerto Rico.

Insect damage.--In 1950 and subsequent years the destructive armyworm was found feeding on the cereal plants. Chlordane was sprayed on the plant for

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3/ Roure, L. A. The Rust of Puerto Rico. Univ. Puerto Rico Tech. Paper 35: 5-145. 1965.

4/ Personal communication from F. A. Uecher.

5/ Stewart, D. M., and Hill, J. H. Helminthosporium sativum toxic to Puccinia graminis tritici. (Abstract.) U.S. Plant Dis. Rptr. 49: 280-283. 1965.

control. Later, it was injected into the sprinkler irrigation system during the last 10 minutes of irrigation. Periodic surveys were made to determine the percentage of infestation, which, in turn, determined the frequency and rate of application.

Oats

The oat nursery, planted at St. Croix in 1950, was considered successful from the standpoint of crown and stem rust infection. The reaction of Santa Fe, Landhafer, Trispernia, and Ukraine was similar to that determined previously. However, the greatest disappointment was in growth of plants; only one entry headed. Insufficient light and lack of fertilizer probably accounted for this. Because of poor results, the oat nursery was omitted from the program until 1957 when virulent biotypes of crown rust developed.

Information pertaining to the oat nurseries from 1957 to 1972 is shown in table 2 and is discussed under the following topics:

Location.--The oat nurseries were planted at one or more locations each year after 1957. Different locations were used to determine the reaction of (1) the same culture under different conditions or (2) different cultures. Entries from some breeders were planted at all locations while others were planted at only one location. Location for testing entries was based upon the request of the breeder submitting seed. The Ponce location was omitted from the program after the 1963-64 season. Problems in moving equipment and lack of irrigation, personnel, and maintenance necessitated this change.

Before 1969, the experimental area at Mayaguez was large enough to handle 3,000 or more entries. Because of pressures on use of the nursery site, the location was changed and the plot area was reduced in size. Consequently, part of the nursery was planted at Mayaguez and the rest at Isabela.

Supplemental lights, the same as described for wheat, were used for the nursery in 1966 and later years at Mayaguez. Differences in growth stages were evident in plants that had received supplemental light and those without additional light. Data recorded for growth stages are shown in table 3.

Table 3.--Effect of supplemental light on growth of oat plants

Material	1970-71		1971-72	
	Light	No light	Light	No light
	Pct.	Pct.	Pct.	Pct.
International Oat Rust Nursery---------1/	87	7	90	2
A. sterilis----------	79	8	55	14

1/ Percentage of selections, based on 90 to 500 different entries in each nursery.

The data clearly show the value of using supplemental light for growing oats. Although the intensity was low (3 ft.-c.), it was most helpful in getting readings on the adult plant reaction.

Number of plots, entries, and sources of seed.--The oat rust nursery in Puerto Rico required 105,634 plots or rows representing 67,543 selections. These selections included cultivars, Plant Introduction accessions, and genetic material from 62 countries and 44 States within the United States. The 1957 nursery contained an alphabetical listing of cultivars in the World Collection of Small Grains. Entries for later years were primarily genetic materials from different breeders. Since 1963, the nurseries have contained about half the collected material of A. sterilis L. Data from many entries could not be collected because of dormancy of seed and root rot. The percentage of resistant material each year is related to the number of selections submitted by individual breeders.

Races used.--Eleven races and three biotypes of crown rust (P. coronata Cda. var. avenae Fraser & Led.) and two races and three biotypes of stem rust (P. graminis Pers. f. sp. avenae Eriks. & E. Henn.) were used in different years in Puerto Rico. Contamination of plots occurred in only 2 years. The contaminating race was identified in each plot as one from the other location.

The ever-changing importance of crown and stem rust race or biotype is shown in table 2. Virulence in races 264 and 6A changed twice since 1957. Each time the change occurred, the amount of available resistant material for breeding programs also decreased. The frequent changes in the leaf and stem rust populations on oats emphasize the need for continuing annual United States rust surveys. M. D. Simons, Iowa State University, conducts the surveys for crown rust and employees of the Cereal Rust Laboratory, St. Paul, Minn., conduct those for stem rust.

Resistance.--The percentage of oat selections with average disease coefficients of 2 or less are much lower than for wheat. The nursery of 1957-58 had only 2 percent of the total number of entries resistant to race 264. Table 2 shows that virulence of the rust population of race 264 has remained high. The same is true of virulence in stem rust. None of the commercial oat cultivars possess a high degree of resistance. Resistance to crown and stem rust has been found in A. strigosa Schreb. and A. sterilis selections. Few interspecies crossings involving A. strigosa and A. sterilis have been successful. Rapid progress in transfer of resistance from A. sterilis to A. sativa is being made at several locations within the United States.

Problems related to testing oats in Puerto Rico--Lodging.--Heavy rates of fertilization and supplemental lighting often result in severe lodging in plots of A. sterilis. This is worse in row than in hill plantings. Since 1970, oats have been planted in hills, spaced 2 by 2 ft. apart. Lodged plants are more easily separated to facilitate making rust readings through use of this spacing.

Dormant seed.--Dormancy of seed is common in selections of A. sterilis and it persists longer than in common oats. Seed for planting in Puerto Rico is needed soon after the United States harvest; hence, dormancy often has not been broken. This creates a problem in planting A. sterilis. When planted directly in the field, seed germinates poorly. Consequently, seed of A. sterilis is planted in peat pots in the greenhouse at Mayaguez, P.R., and after germination, transplanted to hills in the field. This technique improves the germinability of newly harvested seed.

Seed production.--Seed set has been improved by the use of supplemental lighting. A limited amount of seed of resistant selections can now be harvested in March in Puerto Rico and planted in certain areas of the United States that spring. This procedure has helped to increase the number of generations per year.

Diseases.--Leaf spots, caused by Helminthosporium avenae Eidam., often occurs in Puerto Rico[6/]. This disease, however, apparently does not retard rust development on oats as H. sorokinianum does on wheat.

Plants with root rot have been observed in some years. Symptoms are similar to those caused by H. victoriae Meehan & Murphy, although the disease was not confirmed. The root rot disease complex is not considered important on oats in Puerto Rico, but armyworms are. They are controlled as for wheat.

Early telial development of crown rust frequently occurs on some entries each year. In such cases the host response is difficult to evaluate. A common parent(s) in the pedigree does not appear to be associated with the phenomenon of early telial formation.

6/ Krupinsky, J. M., and Smith, R. T. Avena spp. Reaction to a Virulent Culture of Helminthosporium avenae from Puerto Rico. U.S. Plant Dis. Rptr. 56: 648-651. 1972.

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